RISK MANAGEMENT STRATEGIES FOR GRAIN ELEVATORS HANDLING IDENTITY-PRESERVED GRAINS

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INTRODUCTION

Recent developments in biotechnology, specifically seed types, are changing the nature of grain marketing. Increased production of identity-preserved (IP) grains has exerted pressure on a system previously concerned with handling homogeneous commodities. Demands associated with production, storage, and transportation of specialty grains are driving industry-wide discussion (McVey, Baumel, and Hurburgh; Vandeburg, Fulton, Dooley, and Preckel). In response, grain channel participants are examining risk management strategies that address system adaptation.

The proliferation of specialty grain varieties presents unique challenges for grain elevators. Whereas historically, grain handling could be described as high volume, low maintenance in terms of managerial and logistical requirements, the newer specialty grains demand significant attention to preservation of grain quality attributes (Brewster, Bierre, and Amrbrister). The need for grain quality preservation is complicated by existing elevator binning configurations which are ill-suited to receive, handle, and store larger numbers of smaller volume grain types. Current systems operations are being re-assessed to incorporate greater flexibility in elevation processes.

The nature of a product can have important ramifications upon the appropriate logistical system.[1] The product characteristic literature, as it relates to grain attributes at the elevator, is addressed separately in the economics and engineering literature. The two approaches, which focus on cost/valuation and scheduling/efficiency respectively, yield strong implications for one another's work.

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[1] Fisher, Marshall. "What is the Right Supply Chain for Your Product?" *Harvard Business Review.* March-April 1997, pp. 105-116.

Ladd and Martin's input characteristics model (ICM) examines the marginal valuation of input characteristics in the production process and reinforces the role that product characteristics play in determining final product demand. Wilson and Preszler extend the ICM to account for technical coefficient uncertainty. They find that uncertainty surrounding end-use performance invites higher ingredient cost, a claim supported by the positive correlation between product characteristic variability and its shadow price.

Previous studies in the agricultural engineering literature have used simulation modeling techniques to examine elevator systems operations with bulk commodity characteristics (Csaki and Maier; King; Baker et al.; Herrman). Herrman's analysis examined whether elevators could capture a premium on grain attributes based on existing excess capacity. The cost floor associated with a commercial elevator, constrained by a single receiving pit and bucket elevator leg, is calculated to be $1.83 per ton.

Desirable management strategies offer greater flexibility for scheduling, testing, and sorting of specialty grains. The objective of this paper is to evaluate costs and efficiencies associated with multiple grain type deliveries. We extend the existing literature by incorporating specialty grains into systems operations. The scope of this paper is confined to the scheduling of multiple-type grain deliveries to an Indiana elevator.[2] Specifically, the impact of receiving additional types of grain at a trainloading elevator is assessed from point of arrival to the dump pit(s). Stochastic simulation techniques are based on historical harvest delivery data provided by a trainloading elevator in central Indiana. Results yield the time requirements and dollar costs for the elevator across operations techniques and the number of grains accepted at the facility. The resulting cost/value measurements aim to improve the information set for system users.

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[2] This paper is the first phase in a larger project evaluating the impacts of introducing multiple grain types on elevator management practices.

Ultimately, implementation of cost minimizing operations practices should offer greater management flexibility while maintaining system efficiency.

Organization of the paper is as follows. The first section provides an overview of the Indiana grain market and profile of the elevator modeled. Second, we discuss model specification, employed simulation techniques, and scenarios modeled. Third, we provide simulation results and their implications. The final section summarizes our findings.

INDIANA GRAIN PROFILE

Grain production in Indiana is heavily weighted towards corn and soybeans, with nominal amounts of wheat produced. As per 1999 production estimates, Indiana ranked 5th nationally in corn production (748.4 million bushels), 4th in soybean production (216.8 million bushels), and 19th in wheat production (33.7 million bushels) (Table 1).

Table 1. Indiana Grain Production and Stocks, December 1, 1999 (million bushels)

Grain	Produced (million bushels)	On-farm stocks		Off-farm stocks		Total all positions	
		Quantity (M bu)	Percent of harvest	Quantity (M bu)	Percent of harvest	Quantity (M bu)	Percent of harvest
Corn	748.4	410	55%	202.4	27%	612.4	82%
Soybeans	216.4	100	46%	61.5	28%	161.5	74%

SOURCE: United States Department of Agriculture, *Crop Production Report, 1999 Summary,* Cr Pr 2-1 (00) a, National Agricultural Statistics Service, Washington, DC, 2000 (usda.mannlib.cornell.edu/reports/nassr/field/pcp-bban/cropan00.pdf).

Indiana grain stock statistics indicate on-farm storage is used for the majority of the grain. At the end of December, approximately half of corn and soybean production, 55% and 46% respectively, is stored on-farm (Table 1). Year-end off-farm storage accounts for less than one-third of corn and soybean production (27% and 28% respectively).

The Indiana based elevator serving as the prototype for the economic-engineering model has a capacity of 6 million bushels. The privately owned elevator is looking to increase facility flexibility based on an expectation of increased types of grains being produced in its trade region. Relative to 1999, they project a decrease in specialty grain production in 2000, while acknowledging market volatility. Data are based on 1999 delivery and handling figures provided by elevator management.

Relative to other terminal elevators in Indiana, the elevator modeled is larger and does not have barge facilities. Of 31 terminal elevators registered with Indiana Grain and Feed Association (IGFA), the mean storage capacity was 3,654,000 bushels. The average country elevator capacity is 910,000 bushels.[3]

RESEARCH METHOD

The economic model simulates operations at an Indiana grain elevator for a single harvest day, October 21, 1999. Costs, quantities, and time intervals used in this analysis are based on historical delivery and operations data provided by elevator management. We use EXTEND® to model stochastic elevator processes involved with receiving grain. Simulated stochastic variables yield cost values subject to repeated iterations, identifying a cumulative cost distribution.

Two alternative scenarios are compared against a baseline case, which models an elevator receiving the traditional homogeneous corn and soybeans. The additional scenarios change the number of grains handled by the elevator.

The baseline case assumes two types of grain, No. 2 yellow corn and No. 1 soybean, are handled by the elevator (Table 2). The data include wet and dry moisture content characteristics

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[3] Elevators with a capacity under 50,000 bushels were not included in the calculation.

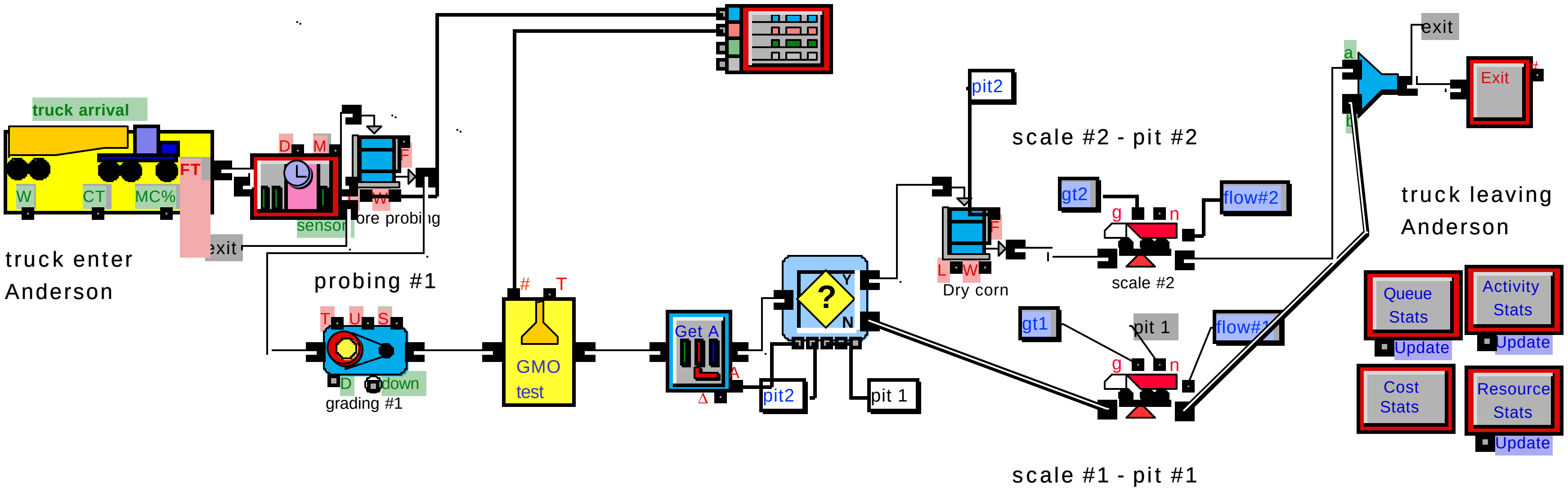
by truckload received from the farm. Grain attributes (moisture content, foreign material, and grain weight) are taken from the data. Thus, the elevator is set to accommodate 2 types of grain, with wet and dry characteristics of each. The second scenario considers an elevator that handles only a single crop, with wet and dry grain attributes. This scenario is included to highlight cost effects for the addition of even bulk commodities. The third scenario assumes the elevator handles a GMO and non-GMO type of both corn and beans, increasing the total number of grains received to eight. The addition of GMO grains also alters testing requirements, increasing test time from two to ten minutes.

MODEL SPECIFICATION

The model incorporates historical data for grain deliveries from the 1999 harvest season. Specifically, a single day, October 21, 1999, is modeled for assorted grain type arrivals. Figure 1 provides the model flow chart, identifying truck arrival through probing, weighing, and dumping processes, to truck departure. Attributes of delivery trucks, grain type, and testing procedures provide a springboard for stochastic variable generation. Distributions for stochastic variables are assigned using the program BestFit®.

The elevator modeled has a total capacity of 6 million bushels and handles an average of 200 trucks per day during the harvest season. Truck arrival is characterized by an exponential distribution with a mean arrival interval of 10 minutes. Allowances are made for two types of truck, hopper-bottom or hoist axle. The probability associated with each type of truck arrival is 72% and 28%, respectively. The average net weight of a hopper-bottom truck is 1052 pounds with a standard deviation of 108 pounds. The average net weight of a hoist axle truck is 514 pounds with a standard deviation of 177 pounds. Within the 2 truck types are 4 sub-types:

Figure 1. Model Flow Chart.



wagon, single axle, double axle, and semi. Scheduling of trucks within the unloading area is limited to a capacity of 11 trucks in the weigh station/grain testing area. First in first out (FIFO) queuing practices are imposed. Tables 2 and 3 provide additional assumptions regarding variable definition. Assumptions regarding receiving pits are outlined in Table 4.

Table 2. Grain Distribution by Model

Model	Variable	Probability
Single grain type	wet corn	50.0%
	dry corn	50.0%
Baseline	wet corn	25.0%
	dry corn	25.0%
	wet soybeans	25.0%
	dry soybeans	25.0%
Add Non-GMO Grains	wet corn	21.0%
	dry corn	24.0%
	wet soybeans	21.0%
	dry soybeans	26.0%
	non-GMO wet corn	1.8%
	non-GMO dry corn	1.8%
	non-GMO wet soybeans	1.8%
	non-GMO dry soybeans	1.8%

Table 3. Model Assumptions

Variable	Comment
Maximum number of trucks per day	200
Hours of elevator operation	7:00 a.m. – 10:00 p.m.
Maximum queue length in staging area	11 trucks
Bulk probe time: baseline model	2 minutes
Bulk probe time: non-GMO grains model	10 minutes
Non-GMO test time	10 minutes
Non-GMO test cost	$7.00

Table 4. Receiving Pit Assumptions

Variable	Comment
Number of pits at elevator	2
Maximum capacity	1,250 bushels
Flow rate	400 bushels/minute
Cleaning time/receiving pit	4 minutes

EMPIRICAL RESULTS

Introducing complexity into elevator operations, via grain types, results in additional time requirements and increased dollar costs, confirming our expectation (Table 5). Two measures highlighted here are elevator efficiency and average cost per truck. Together, they provide important reference points for (later) comparison of management strategies.

While the focus of this section is the comparison of baseline versus added non-GMO scenarios, we draw brief attention to the single grain and baseline case. The cost of simply doubling bulk commodities handled by the facility can be attributed to increased cleaning requirements. Multiplying the elevator process two-fold, for even bulk commodities, translates to an average per truck increase of almost $8.00.

Table 5. Results

	Single Grain Case	Baseline	Add Non-GMO Grains
Trucks received	193	193	129
Capacity utilization	96.5%	96.5%	64.5%
Avg. wait times			
- entering elevator	0 minutes	25 minutes	305 minutes
- in staging area	1 minute	27 minutes	0 minutes
Total cost/day	$3022.18	$4463.82	$3376.89
Average cost/truck	$15.66	$23.13	$26.17

Baseline results indicate an ability to accommodate 193 of the total 200 trucks, or an efficiency level of 96.4%. While the single grain scenario also indicates a capacity utilization level of 96.4%, this single statistic can be misleading before comparison of average truck costs. The total daily baseline cost is $4,463.82, which translates to a per truck cost of $23.13. Average wait time to enter the elevator is 26 minutes. Average wait time in the staging (testing) area, given space constraints, is 28 minutes.

By comparison, the added non-GMO scenario only achieves a 64.5% percent efficiency level. Total daily costs sum to $3,376.89 with an average truck cost of $26.17. These numbers imply that the introduction of non-declared GMOs results in (i) an almost 32% loss of efficiency and (ii) an additional cost of 11.6% ($3.04) per truck. We attribute this to the decrease in system utilization, which is being compromised as additional complexity is introduced to the system.

The wait time for entry, 305 minutes, suggests that testing has become the bottleneck in the system. At most, the elevator can handle 6 trucks per hour now. The additional wait time can be explained in part by the change in bulk probe time. Under the baseline case, test time is 2 minutes. When the non-GMO grains are included, the single-file queue is adversely affected by the 10-minute wait time on non-GMOs. For bulk probing, this means the prior 2-minute test time is inaccurate. The increase in testing delay is coupled with the 11-truck capacity in the staging area. We recognize that additional specifications to the non-GMO testing are warranted and are in process.

CONCLUSIONS

Results address two important and related relationships. The first is the inverse relationship between product complexity and elevator efficiency. This is linked by machine utilization. As the number of grains with different moisture contents increase, the utilization–efficiency relationship becomes more pronounced. The ability of the elevator to accommodate 4 types of grains, which vary by attributes, involves switching costs that compromise efficiency. Testing and clean down times adversely affect machine utilization. Clearly, product complexity and efficiency are not linearly related. Efficiency levels dropped by 1/3 with the introduction of non-declared GMOs. In addition, the difference in marginal truck processing costs for bulk and non-GMOs can be traced back to the reduced machine utilization.

In terms of scheduling, the 10-minute time requirement for non-GMO testing shifts the queuing priority to the front of the elevator. Management strategies that mitigate entry wait time will reduce the additional $3.04 cost per non-declared GMO truck delivery.

For systems considering handling the 3 different categories, bulk commodity, non-declared GMOs, and GMOs, this presents a significant challenge in identifying strategies that compromise neither efficiency not profits. The next phase of this study will examine optimal routing and blending issues at the elevator, allowing for comparison of management strategies.

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